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PROVISIONAL SPECIFICATION

# Improvements in or relating to fuel oils for gas turbine engines.

We, ANGLO-IRANIUM OIL COMPANY LIMITED, of Britannic House, Finsbury Circus, London, E.C.2, a British joint-stock Corporation and DONALD ALBERT HOWES of 610, Fifth Avenue, New York, United States of America, of British Nationality, do hereby declare the nature of this invention to be as follows :—

The invention relates to the production of a fuel for gas turbine engines, and has among its objects to provide a fuel for gas turbine engines by the use of which the build-up of scale upon the turbine blades is eliminated or the rate of build-up greatly reduced.

The fuel customarily employed in gas turbine engines is the residue fraction obtained from petroleum after the light boiling constitutents, contained in the gasoline, naphtha and kerosene fractions, have been removed by distillation. This residue fraction may possess a high content of inorganic materials, the nature and quantity of which is dependent upon the source of the crude petroleum.

In the gas turbine, fuel is injected into a combustion zone and is ignited in the presence of an excess of air, the products of combustion being directed towards turbine blades having carefully designed contours, whereby the energy of the gas stream is converted into rotary energy. The efficiency of conversion is high. Certain of the inorganic materials present in the fuel, however, fail to remain in the gas stream after combustion and deposit in the turbine engine, to form a scale, notably on the rotor and stator blades, resulting in a decrease in the efficiency of the engine, and necessitating the shutting-down of the unit at frequent intervals for cleaning of the blades and other parts of the engine on which the scale has deposited.

It has been found that the formation of this scale is attributable to the presence of vanadium compounds in the fuel, and in the case of fuels wherein the vanadium content exceeds 0·03 per cent. by weight, the rate of build-up of scale reaches such a degree as to reduce materially the value of the fuel in its application to gas turbine engines.

It is among the objects of the invention to provide a petroleum fuel, derived from a petroleum residue fraction which may have a high vanadium content, which is suitable for use as a gas turbine fuel and in which the disadvantages hereinbefore referred to are materially reduced. More particularly it is among the objects of the invention to provide a fuel for gas turbine engines which materially reduces or which avoids the formation of scale upon the interior surfaces of a gas turbine engine, such as upon the rotor and stator blades.

According to the invention a fuel suitable for use in gas turbine engines is obtained by a process which comprises treating a petroleum residue fraction, containing at least 0·03 per cent. by weight of vanadium in combined form with normal hexane or normal heptane or a mixture of these solvents, or a solvent containing normal hexane and/or normal heptane in major proportions, and thereafter separating the solution so obtained from the insoluble material in the solvent.

By operating according to the above process, it has been found possible to remove a large proportion of the vanadium compounds in association with the hard asphalt present in the residue as material insoluble in the solvent. After separation of the insoluble material, the solvent is stripped from the residue fraction, and the fraction thus refined, with or without blending or further treatment, is suitable for use as a gas turbine fuel.

The invention is illustrated, but in no way limited, by the following example—

*EXAMPLE.*

A 12·4 per cent. residue fraction derived from a Middle East crude petroleum oil was treated at ordinary temperatures with 800 per cent. by weight of petroleum ether of boiling range 60°C. to 80°C. The solution

[*Price*

so formed was allowed to stand for a few hours and then the insoluble material was filtered off and the resulting solution distilled to remove the petroleum ether solvent.

| | |
|---|---|
| 12·4 per cent. Residue from Middle East Crude | 100 parts by wt. |
| Material insoluble in the solvent | 19·5 parts by wt. |
| Vanadium content of unreacted material | 0·065 parts by wt. |
| Vanadium content of material insoluble in the solvent, (that is 0·22 per cent. by weight of insoluble material) | 0·043 parts by wt. |
| Treated residue | 80·5 parts by wt. |
| Vanadium content of treated residue fraction (that is 0·024 per cent. by weight of treated residue) | 0·019 parts by wt. |

Thus, by the process of the invention the vanadium content is reduced from 0·065 per cent. by weight of the 12·4 per cent. Residue to 0·024 per cent. by weight of the treated residue, the fuel so obtained being particularly suitable for gas turbine engines.

Dated the 7th day of November, 1947.

EDWARD EVANS & CO.,
14-18, High Holborn, London, W.C.1.
Agents for the Applicants.

PROVISIONAL SPECIFICATION

## Improvements in or relating to fuel oils for gas turbine engines.

We, ANGLO-IRANIAN OIL COMPANY LIMITED, of Britannic House, Finsbury Circus, London, E.C.2, a British joint-stock Corporation and DONALD ALBERT HOWES of 610 Fifth Avenue, New York, United States of America, of British nationality, do hereby declare the nature of this invention to be as follows:—

The invention relates to the production of a fuel for gas turbine engines, and has among its objects to provide a fuel for gas turbine engines by the use of which the build-up of scale upon the turbine blades is eliminated or the rate of build-up greatly reduced.

In the gas turbines, fuel is injected into a combustion zone and is ignited in the presence of an excess of air, the products of combustion being directed towards turbine blades having carefully designed contours, whereby the energy of the gas stream is converted into rotary energy. The efficiency of conversion is high. Although it is desirable for various reasons to use cheap residual fuels, it has been found that the use of such fuels is severely limited by the fact that in many instances certain of the inorganic materials present in the fuel, fail to remain in the gas stream after combustion and deposit in the turbine engine to form a scale, notably on the rotor and stator blades, resulting in a decrease in the efficiency of the engine, and necessitating the shutting-down of the unit at frequent intervals for cleaning of the blades and other parts of the engine on which the scale has deposited.

It has been found that the presence of vanadium compounds in the residual fuel is largely responsible for the formation of this scale, and that in order to prevent the build-up of scale from reaching such a degree that it materially reduces the value of the fuel in its application to gas turbine engines it is necessary to reduce the vanadium content of the fuel to below 0·03 per cent. wt. and preferably to eliminate it entirely.

It is among the objects of the invention to provide a petroleum fuel, derived from a petroleum residue fraction which may have a high vanadium content, which is suitable for use as a gas turbine fuel and in which the disadvantages hereinbefore referred to are meterially reduced. More particularly it is among the objects of the invention to provide a fuel for gas turbine engines, the use of which materially reduces or avoids the formation of scale upon the interior surface of a gas turbine engine, such as upon the rotor and stator blades.

According to the invention a fuel suitable for use in gas turbine engines is obtained by a process which comprises treating a petroleum residue fraction, containing vanadium in elemental or combined form, with a solvent containing one or more hydrocarbons having 3-7 carbon atoms per molecule and thereafter separating the solution so obtained from the material in soluble in the hydrocarbon or hydrocarbons.

The preferred hydrocarbons are normal hexane and normal heptane, or there may be used a mixture of these hydrocarbons, or a solvent containing normal hexane and/or normal heptane in major proportions.

Preferably the petroleum residue fuel is treated with about 800 per cent. by volume of the hydrocarbon-containing solvent.

By operating according to the above process, it has been found possible to remove all or a large proportion of the vanadium compounds in the residue as material insoluble in the solvent. After separation of the insoluble material, the solvent is usually stripped from the residue fraction, and the fraction thus refined, with or without blending or further treatment, is

suitable for use as a gas turbine fuel.

The process of the invention is most advantageously applied to petroleum residue fractions having a total vanadium content of at least 0·03 per cent. by weight, estimated as elemental vanadium.

The invention is illustrated but in no way limited by the following Examples.

*EXAMPLE I*

A 12·4 per cent. residue fraction derived from a Middle East crude petroleum oil was treated at room temperature with 800 per cent. by weight of petroleum ether of boiling range 60°C. to 80°C. The solution so formed was allowed to stand for a few hours and then the insoluble material was filtered-off and the resulting solution distilled to remove the petroleum ether solvent.

Distribution of vanadium was found to be as shown in the following table.

| | |
|---|---|
| 12·4 per cent. Residue from Middle East Crude. | 100 parts by wt. |
| Material insoluble in the Solvent. | 19·5 „ „ „ |
| Vanadium content of unreacted material. | 0·065 „ „ „ |
| Vanadium content of material insoluble in the solvent (that is 0·22 per cent. by weight of insoluble material). | 0·043 parts by wt. |
| Treated residue. | 80·5 „ „ „ |
| Vanadium content of treated residue fraction (that is 0·024 per cent. by weight of treated residue). | 0·019 „ „ „ |

Thus, by the process of the invention the vanadium content is reduced from 0·065 per cent. by weight in the untreated residue to 0·024 per cent. by weight in the treated residue, the fuel so obtained being particularly suitable for gas turbines.

*EXAMPLE II*

1 volume of a 16·7 per cent. by volume residue fraction derived from a Middle East crude petroleum oil and having a vanadium content of 0·012 per cent. was treated at 140°F. with 8 volumes of a hydrocarbon solvent. Insoluble material was separated by filtration and the resulting solution distilled to remove the hydrocarbon solvent. Distribution of vanadium between treated residue and precipitate was found to be as shown by the following table based on the treatment of 100 parts by weight of residue.

| Solvent | Process Yield, Parts by Weight | | Vanadium Content, % by weight | |
|---|---|---|---|---|
| | Treated Residue | Precipitate | Treated Residue | Precipitate |
| Propane | 20.1 | 79.9 | Nil | 0.015% of fraction 100% of total |
| Butane | 68.0 | 32.0 | 0.0022% of fraction 12.5% of total | 0.033% of fraction 87.5% of total |
| Iso-butane | 48.0 | 52.0 | 0.0009% of fraction 3.8% of total | 0.022% of fraction 96.2% of total |
| Pentane | 81.7 | 18.3 | 0.0041% of fraction 27.7% of total | 0.047% of fraction 72.3% of total |
| Hexane | 85.7 | 14.3 | 0.0062% of fraction 44.5% of total | 0.047% of fraction 55.5% of total |

*EXAMPLE III.*

A 25·2 per cent by volume residue fraction derived from a Middle East crude petroleum oil and having a vanadium content of 0·0307 per cent. by weight was treated with 8 times its volume of propane in a counter-current tower operated at 150°F., tower top, and 110°F., tower base; the treated residue constituted 36 per cent. by weight of the feedstock and contained no vanadium.

*EXAMPLE IV.*

The residue fraction described in Example III was treated batchwise with 8 times its volume of 60-80°C. boiling range paraffinic petroleum ether at room temperature. The treated residue constituted 90 per cent. by weight of the feedstock and contained 0·0166 per cent. by weight of vanadium.

Dated this 23rd day of September, 1948.

EDWARD EVANS & CO.

14S18 High Holborn, London, W.C.1.

Agents for the Applicants.

COMPLETE SPECIFICATION

# Improvements in or relating to fuel oils for gas turbine engines.

We, ANGLO-IRANIAN OIL COMPANY LIMITED, of Britannic House, Finsbury Circus, London, E.C.2, a British joint-stock Corporation and DONALD ALBERT HOWES, of 610, Fifth Avenue, New York, United States of America, of British nationality do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention relates to the production of a fuel for gas turbine engines, and has among its objects to provide a fuel for gas turbine engines by the use of which the build-up of scale upon the turbine blades is eliminated or the rate of build-up greatly reduced.

In the gas turbines, fuel is injected into a combustion zone and is ignited in the presence of an excess of air, the products of combustion being directed towards turbine blades having carefully designed contours, whereby the energy of the gas stream is converted into rotary energy. The efficiency of conversion is high. Although it is desirable for various reasons to use cheap residual fuels, it has been found that the use of such fuels is severely limited by the fact that in many instances certain of the inorganic materials present in the fuel, fail to remain in the gas stream after combustion and deposit in the turbine engine to form a scale, notably on the rotor and stator blades, resulting in a decrease in the efficiency of the engine, and necessitating the shutting-down of the unit at frequent intervals for cleaning of the blades and other parts of the engine on which the scale has deposited.

It has been found that the presence of vanadium compounds in the residual fuel is largely responsible for the formation of this scale and that, in order to prevent the build-up of scale from reaching such a degree that it materially reduces the value of the fuel in its application to gas turbine engines, it is necessary to reduce the vanadium content of the fuel to below 0·03 per cent. and preferably to eliminate it entirely.

It is among the objects of the invention to provide a petroleum fuel, derived from a petroleum residue fraction which may have a high vanadium content, which is suitable for use as a gas turbine fuel and in which the disadvantages hereinbefore referred to are materially reduced. More particularly it is among the objects of the invention to provide a fuel for gas turbine engines, the use of which materially reduces or avoids the formation of scale upon the interior surfaces of a gas turbine engine such as upon the rotor and stator blades.

According to the invention a fuel suitable for use in gas turbine engines is obtained by a process which comprises intimately admixing a petroleum residue fraction, preferably constituting not more than 30 per cent. by volume on the crude petroleum, containing vanadium in elemental or combined form, with a solvent consisting of one or more paraffin hydrocarbons having 5–7 carbon atoms per molecule, the solvent containing not more than 0·5 per cent. by weight of aromatics and being substantially free of naphthones and thereafter separating the solution so obtained from the material insoluble in the said solvent.

The preferred hydrocarbons for use as solvent are normal hexane and normal heptane or there may be used a mixture of these hydrocarbons, or a solvent mixture containing normal hexane and/or normal heptane. Preferably the total weight of normal hexane and normal heptane in the solvent constitutes at least 50 per cent.

Preferably the petroleum residue fuel is intimately admixed with at least 500 per cent. and, more desirably with about 800 per cent. by volume of the solvent.

By operating according to the above process, it has been found possible to remove all or a large proportion of the vanadium or vanadium compounds in the residue as material insoluble in the solvent. After separation of the insoluble material, the solvent is usually stripped from the residue fraction, and the fraction thus refined, with or without blending or further treatment, is suitable for use as a gas turbine fuel.

The process of the invention is most advantageously applied to petroleum residue fractions having a total vanadium content of at least 0·02 per cent. and preferably more than 0·03 per cent. by weight, estimated as elemental vanadium.

The invention is illustrated but in no way limited by the following examples.

*EXAMPLE I.*

A 12·4 per cent. by volume residue fraction derived from a Middle East crude petroleum oil was intimately admixed at 20°C. with 800 per cent. by weight of petroleum ether of boiling range 60°C. to 80°C. The solution so formed was allowed to stand for a few hours and then the insoluble material was filtered off and the resulting solution distilled to remove the petroleum ether solvent.

Distribution of vanadium was found to be as shown in the following table.

12·4 per cent. Residue from Middle East Crude 100 parts by wt.
Material insoluble in the solvent 19·5 parts by wt.
Vanadium content of unreacted material 0·065 parts by wt.
Vanadium content of material insoluble in the solvent (that is 0·22 per cent. by weight of insoluble material) 0·043 parts by wt.
Treated residue 80·5 parts by wt.
Vanadium content of treated residue fraction (that is 0·024 per cent. by weight of treated residue) 0·019 parts by wt.

Thus, by the process of the invention the vanadium content is reduced from 0·065 per cent. by weight in the untreated residue to 0·024 per cent. by weight in the treated residue, the fuel so obtained being particularly suitable for gas turbines.

*EXAMPLE II.*

1 volume of a 16·7 per cent. by volume residue fraction derived from a Middle East crude petroleum oil and having a vanadium content of 0·012 per cent. was treated at 140°F. with 8 volumes of a hydrocarbon solvent. Insoluble material was separated by filtration and the resulting solution distilled to remove the hydrocarbon solvent. Distribution of vanadium between treated residue and precipitate was found to be as shown by the following table based on the treatment of 100 parts by weight of residue.

| Solvent | Process Yield, Parts by Weight: Treated Residue | Process Yield, Parts by Weight: Precipitate | Vanadium Content, % by weight: Treated Residue | Vanadium Content, % by weight: Precipitate |
|---|---|---|---|---|
| Propane | 20.1 | 79.9 | Nil | 0.015% of fraction 100% of total |
| Butane | 68.0 | 32.0 | 0.0022% of fraction 12.5% of total | 0.033% of fraction 87.5% of total |
| Iso-butane | 48.0 | 52.0 | 0.0009% of fraction 3.8% of total | 0.022% of fraction 96.2% of total |
| Pentane | 81.7 | 18.3 | 0.0041% of fraction 27.7% of total | 0.047% of fraction 72.3% of total |
| Hexane | 85.7 | 14.3 | 0.0062% of fraction 44.5% of total | 0.047% of fraction 55.5% of total |

*EXAMPLE III.*

A 25·2 per cent. by volume residue fraction derived from a Middle East crude petroleum oil and having a vanadium content of 0·0307 per cent. by weight was treated with 8 times its volume of propane in a countercurrent tower operated at 150°F., tower top, and 110°F., tower base. The treated residue constituted 36 per cent. by weight of the feedstock and contained no vanadium.

*EXAMPLE IV.*

The residue fraction described in Example III was treated batchwise with 8 times its volume of 60–80°C. boiling range paraffinic petroleum ether at room temperature. The treated residue constituted 90 per cent. by weight of the feedstock and contained 0·0166 per cent. by weight of vanadium.

The process of "de-asphalting" by the treatment of petroleum residue fractions with paraffins of low molecular weight or with light petroleum oils is well known. The present invention is directed to the production of fuels of particular value for use in gas turbine engines from mineral oil sources hitherto considered unsuitable for this purpose and no claim is made to the process of "de-asphalting" other than as applied to the particular feedstocks and under the conditions of treatment as claimed hereinafter.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A process whereby a petroleum residue fraction containing vanadium in elemental or combined form is rendered suitable for use as a fuel for gas turbine engines, which comprises intimately admixing the petroleum residue fraction, with a solvent consisting of one or more paraffin hydrocarbons having 3–7 carbon atoms per molecule the solvent containing not more than 0·5 per cent. by weight of aromatics and being substantially free of naphthenes and thereafter separating the solution so

obtained from the material insoluble in the hydrocarbon or hydrocarbons.

2. A process according to claim 1, in which the solvent is stripped from the solution and recycled for the treatment of fresh feed.

3. A process according to either of claims 1, or 2, in which the solvent is normal hexane, normal heptane, mixtures thereof or solvent mixtures containing normal hexane and/or normal heptane wherein the total weight of normal hexane and normal heptane constitutes at least 50 per cent. by weight of the solvent.

4. A process according to any of the preceding claims, in which the petroleum residue fraction has a total vanadium content of at least 0·02 per cent. by weight, estimated as elemental vanadium.

5. A process according to claim 4, in which the vanadium content is at least 0·03 per cent. by weight, estimated as elemental vanadium.

6. A process according to any of the preceding claims, in which the petroleum residue fraction is intimately admixed with at least 500 per cent. by volume of solvent.

7. A process according to any of the preceding claims, in which the petroleum residue fraction constitutes not more than 30 per cent. by volume on the crude petroleum.

8. A process for the production of a fuel oil substantially as described with reference to any of the foregoing examples.

9. Fuel oil whenever produced by a process as claimed in any of the preceding claims.

Dated the 8th day of November, 1948.

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